

**Remarks**

Claims 10-12, 14, and 15 are pending in this application and stand rejected. Claim 10 is independent. No claims have been amended, added or canceled by this response. This Response After Final raises no new issues, but merely reiterates, in a more specific manner, that the claims are in a form that are clearly patentable over the prior art of record. This Response After Final also reduces the issues for appeal. Therefore, Applicant's respectfully request entry of this response, reconsideration and allowance of rejected claims 10-12, 14 and 15.

The Office Action rejected claims 10-12 and 14 under 35 U.S.C. § 103(a) as being unpatentable over Beaujean et al. (U.S. Patent No. 5,505,875); and rejected claims 10-12, 14, and 15 under 35 U.S.C. § 103(a) as being unpatentable over Brichard (U.S. Patent No. 4,421,669).

Applicant respectfully traverses the Section 103(a) rejections.

Applicant discloses a novel and non-obvious inventive process for the production of particulate detergents or pre-mixes suitable for their production by application of a flowable acidic component, stearic acid, to a particle consisting of at least partly an alkaline detergent. The percentage of acidic component applied is characterized by the formula  $m_c/(m_c + m_p) = c \cdot 1/r$ , where  $m_c$  is the weight of the acidic component applied,  $m_p$  is the weight of the particle,  $r$  is the radius of the particle in  $\mu\text{m}$ , and  $c$  is a factor of 0.5 length units to 20 length units. The use of stearic acid as the sole flowable acid coating component results in the unexpected benefit of creating a particularly dense and *comparatively sparingly or slowly water soluble coating*. (See the Specification page 3 lines 23 *et seq.*) This stearic acid based coating remains reliably

impermeable after introduction into an aqueous system but facilitates the production of detergents with a stepped pH profile via a neutralization reaction between the acidic coating material, stearic acid, and the alkaline particle on the surface of the particle.

Beaujean '875 discloses a storage stable water *insoluble* encapsulate, sodium percarbonate, and process for its production. The '875 reference teaches the exposure of percarbonate particles to a molten fog of a mixture of materials for use in *insoluble* encapsulation which is formed by rapid cooling. (See Col. 5 lines 1-65). A preferred embodiment and best mode of the '875 reference is described as a three component encapsulate consisting of 25-60 percent by weight paraffin wax, 10-60 percent by weight of microcrystalline paraffin and 5 to 20 percent diamides derived from C<sub>2-7</sub> diamines and saturated C<sub>12-22</sub> fatty acids. The '875 reference makes a passing broad reference to the use of long chain saturated carboxylic acids and/or corresponding saturated alcohols containing up to 24 carbon atoms. (See Col. 5 lines 30-35). Beaujean makes further reference to long chain saturated carboxylic acids, esters and especially waxes, esters and ethers that have specific solidification ranges. (See Col. 5 lines 35-52). The '875 reference, however, is devoid of any teaching of the use of a coating that is *slowly soluble* by using an acid component, stearic acid, in accordance with the disclosed and claimed formula to establish a stepped pH profile with a the alkaline interface of the particle.

Brichard '669 discloses a process for the stabilization of particles containing peroxygen compounds and bleaching agents using a coating agent which is *insoluble* in water and melts at low temperatures. The '669 reference discloses and claims only the use of waxes for use with the

invention. (See Col. 2 lines 44-50 and claim 1, Col. 12 lines 64-69). The '669 reference teaches the use of waxes based on a various types of products such as high molecular weight hydrocarbons, fatty acids and their derivatives such as esters and amides and fatty alcohols. (See Col. 2 lines 46-49, see also Col. 2 line 51- Col. 3 line 35). The best results are disclosed as being derived from the use of coatings with waxes derived from high molecular weight hydrocarbons. (See Col. 2 lines 49-50, see also Col. 3 lines 20-35). The '875 reference is devoid of any teaching of the use of a coating that is *slowly soluble* by using an acid component, stearic acid, in accordance with the disclosed and claimed formula to establish a stepped pH profile with a the alkaline interface of the particle.

#### **REJECTIONS UNDER 35 USC § 103(a), OBVIOUSNESS**

Claims 10-12 and 14 have been rejected as obvious in light of Beaujean's disclosure of the use of fatty acids as the coating agent and in light of the Examiner's view that the optimal proportions of stearic acid could be discovered through routine experimentation. Claims 10-12, 14, and 15 have also been rejected as obvious in light of Brichard's disclosure of the use of fatty acids as the coating agent and in light of the Examiner's view that the optimal proportions of stearic acid could be discovered through routine experimentation.

Further, the Examiner states that the stepped pH profile of the invention would have been obvious in light of Beaujean or independently in light of Brichard, because each process uses similar process steps and ingredients, creating a reasonable expectation of the presence of a stepped pH profile in the prior art of record.

**However, neither Beaujean nor Brichard use the same materials as the instant application's invention.** Thus the inference of a reasonable expectation of the existence of a stepped pH profile in the prior art of record is in error. Furthermore, the existence of a stepped pH profile in the instant application's invention is an unexpected result of a combination of elements which were both known and unknown in the art. Finally, the stepped pH profile was not disclosed in any of the prior art cited by the Examiner.

In establishing a *prima facie* case of obviousness under 35 U.S.C. 103, the Examiner has the burden of establishing (1) some suggestion or motivation to modify the reference or to combine reference teachings, (2) a reasonable expectation of success, and (3) that the prior art references, when combined, teach or suggest all the claim limitations. See MPEP §2143 (Aug. 2001). "Both the suggestion and the reasonable expectation of success must be found in the prior art, not in the applicants' disclosure." *In re Vaeck*, 947 F.2d 488, 493, 20 USPQ2d 1438 (Fed. Cir. 1991). To glean information from applicant's disclosure as the basis for the reconstruction of the claimed invention from the prior art is impermissible hindsight. *In re McLaughlin*, 443 F.2d 1392, 170 USPQ 209 (CCPA 1971). Furthermore, a showing of the existence of secondary considerations, e.g. unexpected results, must be evaluated by the Examiner in determining a *prima facie* case of obviousness. See MPEP § 2141 (III) (Aug. 2001).

The Examiner has rejected claims 10-12 and 14 as obvious in light of Beaujean, and claims 10-12, 14 and 15 in light of Brichard, because "it would have been obvious to one of ordinary skill in the art at the time the invention was made to reasonably expect the coated

percarbonate product of Beaujean or Brichard to behave similarly because same process steps and similar ingredients have been utilized.” But “similar ingredients” for encapsulation are not recited in the rejected claims. The Examiner has not presented any prior art which describes the use of stearic acid as the acid component for the particle coating nor the interaction of the alkaline surface of a detergent particle with a coating’s acid component to create a stepped pH profile. The Examiner has provided no motivation or suggestion for the modification of the cited prior art in accordance with the law. The Examiner has presented no proof of a reasonable expectation of success for the modifications. The only source for the Examiner’s conclusions on the record is Applicant’s own disclosure. Therefore the Examiner has committed a reversible error by using impermissible hindsight and has not met his burden in establishing a *prima facie* case.

By force of law this is all Applicant needs to establish in rebuttal. *See In re Oetiker*, 977 F.2d 1443, 1445 (Fed. Cir. 1992). However, as evidence of secondary considerations present in the application as filed, such evidence was pointed out to the Examiner to further establish the patentability of the claimed invention. (See Response dated August 26, 2005, page 6 lines 8-16, i.e. the second full paragraph) The Examiner has not evaluated or given any weight to the evidence of secondary considerations presented in the application regarding the unexpected results of the pH stepped profile. This is contrary to the MPEP on the matter of evaluating secondary considerations. See MPEP § 2141 (III) (Aug. 2001).

In regards to the obviousness rejection based upon Beaujean, the rejection is in error

because it does not disclose all the elements of the claimed invention, there is no suggestion or motivation to modify Beaujean, and there is no reasonable expectation of success even if Beaujean could be so modified. Beaujean does not disclose the claimed use of stearic acid as the acid component of the coating of a detergent particle. Beaujean does not disclose the claimed formula for determining the content of the acid component, stearic acid, of the claimed invention to facilitate the interaction of the alkaline particle surface and the acid component, stearic acid. Beaujean does not disclose the creation of a stepped pH profile based upon the interaction of the alkaline interface with the acid component, stearic acid. Beaujean makes a passing reference to the use of the genus of saturated fatty acids with a carbon chain range of up to 24 carbon atoms. Stearic acid falls within this range with a carbon chain range of 18 carbon atoms. However, Beaujean asserts the use of fatty acids as a coating material is equivalent to the use of corresponding saturated alcohols, esters and especially wax esters, fatty acid glycerol esters and alkalolamides with the key concern being solidification range of the compounds for use in their molten fog/rapid cooling coating method. (See Col. 5 lines 1-52 of Beaujean). Therefore the focus of Beaujean is not use of an acid component in the coating but instead purely focuses on the solidification range of the blend of coating materials. (See Col. 5 lines 1-15). Beaujean asserts the materials as being equivalent yet they have varying degrees of acidity. The wax and diamide components used in the preferred embodiment and the claimed invention are not capable of dissociating a hydrogen at all to influence a pH profile, stepped or otherwise. (See Exhibit A, Mathews van Holde, Biochemistry p. 302 Fig 9.4, wax compounds structure and the lack of

hydrogen available for pH influence). If the fatty acids have dissociated their carboxylic hydrogen atoms, i.e. lost their carboxylic acid hydrogens via the esterification process, which forms the preferred wax materials between a fatty acid and an alcohol, then the coating does not have an acid component and can no longer be utilized to donate a hydrogen to interact with the alkaline surface of the particles to establish a stepped pH profile. Just because the invention of Beaujean uses fatty acids as starting compounds to synthesize the wax components used in the invention does not establish that hydrogen donation is available to create a pH profile.

The Official Action asserts that a disclosure is not limited to its examples, which happens to correspond to the claimed invention of Beaujean. (See page 4, lines 1-2 of the Action dated November 28, 2005). The observation by the Examiner is noted but not relevant, because, as noted above, Beaujean is not capable of establishing the stepped pH profile. Even if Beaujean used a fatty acid as its coating, it would be employed in amounts useful for *insolubility* purposes and as part of a moiety of other non-acid *insoluble* components that Beaujean teaches to ensure a proper solidification range is established. Using fatty acids to the point the coating becomes soluble in any way cuts against the disclosed invention of Beaujean. Furthermore, Beaujean would have a multitude of fatty acids to choose from and it would be pure speculation that one would settle upon the stearic acid species as a component for the coating. Then to consciously select the precise percentage of stearic acid to ensure a stepped pH profile adds another layer of speculation upon the use of Beaujean to render the claimed invention obvious.

In the instantly claimed invention the acid component of stearic acid is selected as a

percentage of the coating determined via the claimed formula to establish a slow solubility that facilitates the claimed stepped pH profile. Using Beaujean's broad passing comment that a range of long chain carboxylic acids up to 24 C atoms can be used in as a coating component to conclude that the instantly claimed invention is rendered obvious is impermissible hindsight. (See Beaujean Col. 5 lines 30-34). The object of the Beaujean invention is to form an *insoluble* coating by ensure a proper solidification range of the coating materials exists in the molten coating material's fog zone during coating application. (See Beaujean Col. 5 lines 1-16). Concluding that routine experimentation is all that is needed without any evidence of suggestion or motivation to modify Beaujean in a manner that is contrary to Beaujean's teaching can be only explained by impermissible hindsight. No other evidence to fill the multitude of gaps in Beaujean exists on the record other than Applicant's own disclosure. Accordingly, the rejection is in error, finality should be lifted and the claims allowed to issue.

In regards to the rejection based upon Brichard, the rejection is in error because is does not disclose all the elements of the claimed invention. Brichard does not even disclose the use of any viable acid component as being part of the coating. Brichard discloses the use of fatty acids as the starting materials for making the waxes which are then used to form the components used for the *insoluble* coatings. (See Col. 2 lines 44-69 and claim 1, Col. 12 lines 65-69) If the fatty acids have dissociated their carboxylic hydrogens, i.e. lost their carboxylic acid hydrogens via the esterification process which forms a wax between a fatty acid and an alcohol, then the coating does not have an acid component and can no longer be utilized to donate a hydrogen to interact



with the alkaline surface of the particles to establish a stepped pH profile. (See also Exhibit A, Mathews van Holde, Biochemistry p. 302 Fig 9.4, wax compounds structure and the lack of hydrogen available for pH influence). Thus, it is chemically impossible for the invention of Brichard to render the claimed invention obvious as it does not have a viable acid component. Furthermore, there is no suggestion to modify Brichard in a manner that is suggested by the Examiner. There is no reasonable expectation of success even if Brichard could be so modified, again because such a modification runs contrary to the express teachings of Brichard, namely the formation of *insoluble* coatings with waxes. Brichard does not disclose the claimed use of stearic acid as an acid component of a slowly soluble coating of a detergent particle. Brichard does not disclose the claimed formula for determining the content of the acid component, stearic acid, of the slowly soluble particle coating. Brichard does not disclose the interaction of the alkaline particle surface and the acid component, stearic acid. Brichard does not disclose the creation of a stepped pH profile based upon the interaction of the alkaline interface with the acid component, stearic acid. Accordingly, the cited legal precedent regarding impermissible hindsight, routine experimentation and reasonable likelihood of success as noted above in regards to the rejection of Beaujean are herein incorporated by reference as being applicable to the Brichard based rejection.

For the aforementioned reasons, Beaujean et al. and Brichard, whether taken alone or in any reasonable combination, fail to show both obviousness criteria. Applicant, therefore, respectfully requests that the Section 103(a) rejections of claims 10-12, 14, and 15 be

Application No. 09/718,943  
Response dated February 10, 2006  
Reply to Office Action of November 28, 2005

reconsidered and withdrawn.

### Conclusion

In view of the foregoing remarks, Applicant respectfully requests the reconsideration of this application and timely allowance of pending claims 10-12, 14 and 15.

In the event the Examiner believes that an interview would be helpful in resolving any outstanding issues in this case, the undersigned attorney is available at the telephone number indicated below.

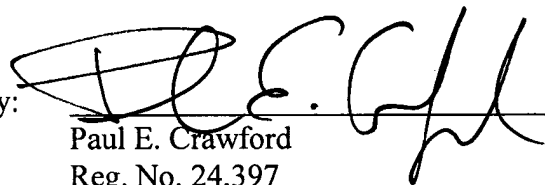
Applicant believes that no fees are due with this response. However, if there are any fees due in connection with the filing of this response, please charge the fees to our Deposit Account No. 03-2775.

Respectfully submitted,

CONNOLLY BOVE LODGE & HUTZ LLP

Dated: February 10, 2006

By:



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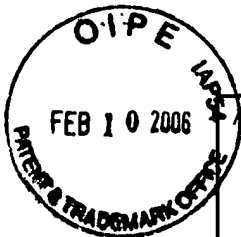
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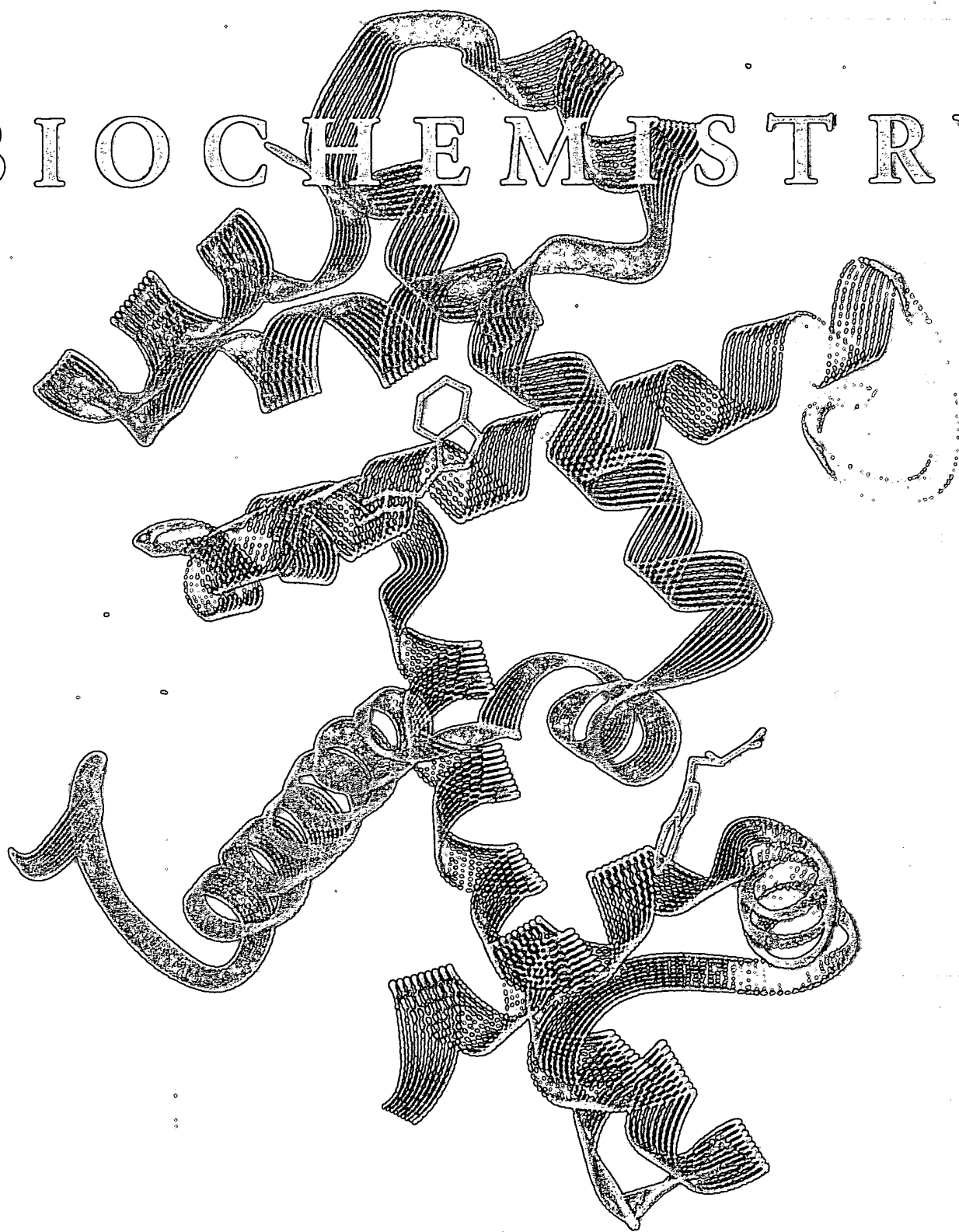
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Request for Reconsideration After Final Rejection (12 pages)  
Exhibit A (8 pages)

# BIOCHEMISTRY



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# BIOCHEMISTRY

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Illustration concepts by Audre W. Newman  
with art contributions from Irving Geis



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### Cover

Dimer of *trp* repressor protein, with bound tryptophan (in blue). The protein binds to DNA and regulates expression of the *trp* genes that control tryptophan biosynthesis. Crystal structure by Paul Sigler et al.; image by Jane and David Richardson.

### Frontispiece

Figure 11.15a The T state of aspartate transcarbamoylase, as determined by x-ray diffraction.

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## CHAPTER 9

# Lipids, Membranes, and Cellular Transport

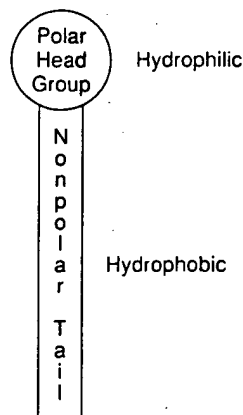
The molecules we encounter in this chapter, the **lipids**, carry out multiple functions. Some—the fats—are used for energy storage, but a large fraction of cellular lipids are used to form the partitions that divide different compartments from one another and separate the cell from its surroundings. These partitions are the **lipid membranes** of the cell. The membranes are much more than passive walls, for they contain highly selective gates that promote the passage of certain materials in certain directions and block others altogether. It is this property of selective membrane permeability that allows each of the different parts of the cell to carry out its specific operations.

In this chapter we first examine the structure and behavior of lipid molecules and then describe the membranes they form and how selective transport through them is accomplished.

### The Molecular Structure and Behavior of Lipids

Unlike the proteins, nucleic acids, and polysaccharides, lipids are not polymers. Rather, they are quite small molecules that have a strong tendency to associate together through noncovalent forces. Lipids are usually characterized by the kind of structure shown in the margin: a polar, hydrophilic “head” region connected to a very hydrophobic hydrocarbon “tail” portion. There are two fundamental reasons lipid molecules in an aqueous environment tend to clump together in noncovalent association. Just as hydrophobic groups in proteins exhibit an entropy-driven hydrophobic effect, so do the nonpolar tails of lipids. A second stabilizing force is the van der Waals interaction between the hydrocarbon regions of the molecules. On the other hand, the polar, hydrophilic head groups on lipid molecules tend to be associated with water. Lipids are, then, prime examples of the kind of amphipathic substance described in Chapter 2.

There are a number of possible consequences of this “molecular schizophrenia,” as shown in Figure 2.16 (Chapter 2). From a biological point of view, the most important is the tendency of lipids to form micelles and membrane bilayers. Exactly what kind of structure is formed when a lipid is in contact with water depends on the specific molecular structure of the hydrophilic and hydrophobic parts of that lipid molecule. Thus, it is appropriate that we now examine some of the major types of lipids.



General lipid structure





Table 9.1  
Some biologically important fatty acids

Common Name	Systematic Name	Abbreviation	Structure	Melting Point (°C)
<b>A. Saturated fatty acids</b>				
Capric	<i>n</i> -Decanoic	10:0	$\text{CH}_3(\text{CH}_2)_8\text{COOH}$	31.6
Lauric	<i>n</i> -Dodecanoic	12:0	$\text{CH}_3(\text{CH}_2)_{10}\text{COOH}$	44.2
Myristic	<i>n</i> -Tetradecanoic	14:0	$\text{CH}_3(\text{CH}_2)_{12}\text{COOH}$	53.9
Palmitic	<i>n</i> -Hexadecanoic	16:0	$\text{CH}_3(\text{CH}_2)_{14}\text{COOH}$	63.1
Stearic	<i>n</i> -Octadecanoic	18:0	$\text{CH}_3(\text{CH}_2)_{16}\text{COOH}$	69.6
Arachidic	<i>n</i> -Eicosanoic	20:0	$\text{CH}_3(\text{CH}_2)_{18}\text{COOH}$	76.5
Behenic	<i>n</i> -Docosanoic	22:0	$\text{CH}_3(\text{CH}_2)_{20}\text{COOH}$	81.5
Lignoceric	<i>n</i> -Tetracosanoic	24:0	$\text{CH}_3(\text{CH}_2)_{22}\text{COOH}$	86.0
Cerotic	<i>n</i> -Hexacosanoic	26:0	$\text{CH}_3(\text{CH}_2)_{24}\text{COOH}$	88.5
<b>B. Unsaturated fatty acids</b>				
Palmitoleic	<i>cis</i> -9-Hexadecenoic	16:1 <sup>Δ9</sup>	$\text{CH}_3(\text{CH}_2)_5\text{CH}=\text{CH}(\text{CH}_2)_7\text{COOH}$	0
Oleic	<i>cis</i> -9-Octadecenoic	18:1 <sup>Δ9</sup>	$\text{CH}_3(\text{CH}_2)_7\text{CH}=\text{CH}(\text{CH}_2)_7\text{COOH}$	16
Linoleic	<i>cis,cis</i> -9,12-Octadecadienoic	18:2 <sup>Δ9,12</sup>	$\text{CH}_3(\text{CH}_2)_4\text{CH}=\text{CHCH}_2\text{CH}=\text{CH}(\text{CH}_2)_7\text{COOH}$	5
Linolenic	all <i>cis</i> -9,12,15-Octadecatrienoic	18:3 <sup>Δ9,12,15</sup>	$\text{CH}_3\text{CH}_2\text{CH}=\text{CHCH}_2\text{CH}=\text{CHCH}_2\text{CH}=\text{CH}(\text{CH}_2)_7\text{COOH}$	-11
Arachidonic	all <i>cis</i> -5,8,11,14-Eicosatetraenoic	20:4 <sup>Δ5,8,11,14</sup>	$\text{CH}_3(\text{CH}_2)_4\text{CH}=\text{CHCH}_2\text{CH}=\text{CHCH}_2\text{CH}=\text{CHCH}_2\text{CH}=\text{CH}(\text{CH}_2)_3\text{COOH}$	-50
<b>C. Branched and cyclic acids</b>				
Tuberculostearic	<i>l</i> -D-10-Methyloctadecanoic		$\text{CH}_3(\text{CH}_2)_7\overset{\text{CH}_3}{\underset{ }{\text{CH}}}(\text{CH}_2)_7\text{COOH}$	13.2
Lactobacillic	$\omega$ -(2- <i>n</i> -octylcyclopropyl)-octanoic		$\text{CH}_3(\text{CH}_2)_5\overset{\text{CH}_2}{\underset{\text{CH}_2}{\text{CH}}}-\text{CH}(\text{CH}_2)_9\text{COOH}$	29

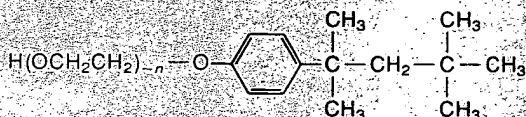
makes it extremely hydrophilic, promoting its solubility in water. At the same time, the long hydrocarbon tails are very hydrophobic. As a result, the fatty acids behave as typical amphipathic substances when we attempt to dissolve them in water. As shown in Figure 2.16 they tend to form monolayers at the air–water interface, with the hydrophilic carboxyl groups immersed and the hydrocarbon tails out of water. If they are shaken with water, fatty acids will make micelles, in which the hydrocarbon tails cluster together within the structure and the carboxylate heads are in contact with the surrounding water.

If fatty acids are mixed with water and an oily or greasy substance (e.g., a hydrocarbon) the micelles will form about droplets of the oil, emulsifying it. This behavior is the basis of the action of soaps and synthetic detergents. Soaps are obtained by hydrolyzing fats with alkalis such as NaOH or KOH (in earlier times, wood ashes were used) in a process called saponification. The fatty acids are released as either sodium or potassium salts, which are fully ionized. However, as cleansers, soaps have the disad-

vantage that the fatty acids are precipitated by the calcium or magnesium ions present in "hard" water, forming a scum and destroying the emulsifying action. Synthetic detergents have been devised that do not have this defect. One class is exemplified by sodium dodecyl sulfate (SDS):



We have already encountered this substance, for it is widely used in forming micelles about proteins for gel electrophoresis. There are also synthetic non-ionic detergents, like Triton X-100:



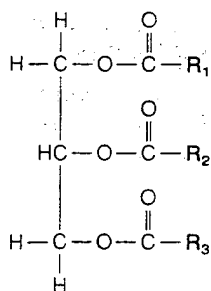
The hydrophilic group here is the polyoxyethylene head group, which in the commercial product averages about 9.5 residues in length.

Although the fatty acids play important roles in metabolism, large quantities of the free acids or their anions are never found in living cells. Instead, they almost always occur as constituents of more complex lipids. We now turn to consideration of some of these classes of biologically important lipid molecules.

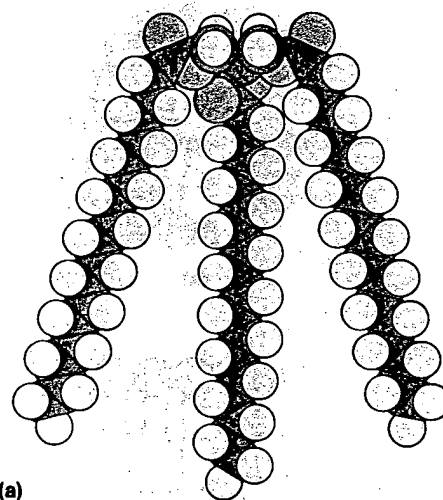
### Triacylglycerols: Fats

The long hydrocarbon chains of fatty acids are extraordinarily efficient for energy storage, because they contain carbon in a fully reduced form and will therefore yield a maximum amount of energy on oxidation. They are, in fact, much more efficient energy stores than are carbohydrates. (Explicit analysis of this difference is made in Chapter 17.) For this reason, lipids are used by many organisms, including humans, for energy storage.

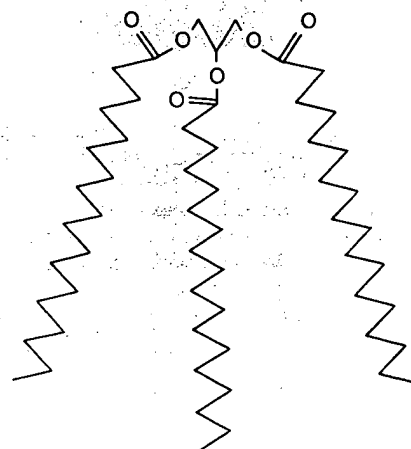
Storage of fatty acids in organisms is largely in the form of triacylglycerols, or fats. These substances are triesters of fatty acids and glycerol; the general formula is



where  $\text{R}_1$ ,  $\text{R}_2$ , and  $\text{R}_3$  correspond to the hydrocarbon tails of various fatty acids. As a particular example, if  $\text{R}_1 = \text{R}_2 = \text{R}_3 = (\text{CH}_2)_{16}\text{CH}_3$ , the molecule tristearin (Figure 9.2) is obtained. Most triacylglycerols, however, contain a mixture of fatty acids, often including unsaturated ones. Table 9.2 lists the composition of some naturally occurring fats. Comparison of common experience with these fats and data in the table reveals an interesting correlation. Fats rich in unsaturated fatty acids (like olive oil) are liquid at room temperature, whereas those with a higher content of saturated fatty acids are more solid. Indeed, a wholly saturated fat is a quite firm solid, especially if the hydrocarbon chains are long. The reason is simple: long saturated chains can pack closely together, to form regular, semicrystalline



(a)



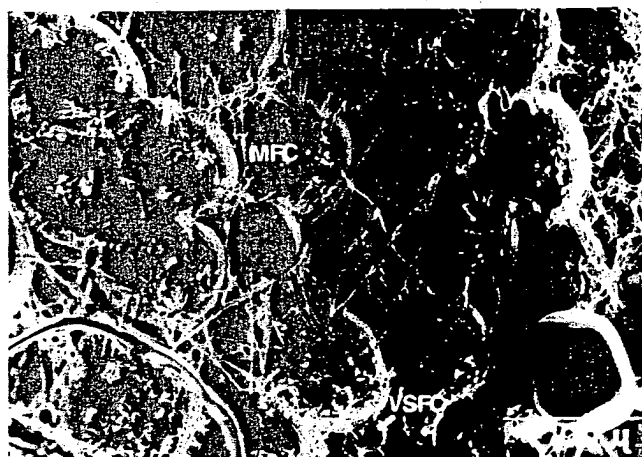
(b)

Figure 9.2  
Tristearin, a fat. (a) Space-filling model; (b) skeletal structure.

Table 9.2  
Composition of some natural fats in percent of total fatty acids<sup>a</sup>

Number of C Atoms in Chain	Olive Oil	Butter	Beef Fat
Saturated			
4-12	2	11	2
14	2	10	2
16	13	26	29
18	3	11	21
Unsaturated			
16-18	80	40	46

<sup>a</sup>Numbers do not total 100% because each substance contains small amounts of other fatty acids.



**Figure 9.3**  
Adipocytes or animal fat storage cells. These are the kinds of cells that make up a large part of adipose tissue.

structures. In contrast, the kind of bend imposed by a cis double bond (see Figure 9.1) makes molecular packing more difficult. Indeed, partial hydrogenation of unsaturated fat oils (like corn oil) is used commercially to produce firmer fats, which can be used as butter substitutes such as oleomargarine.

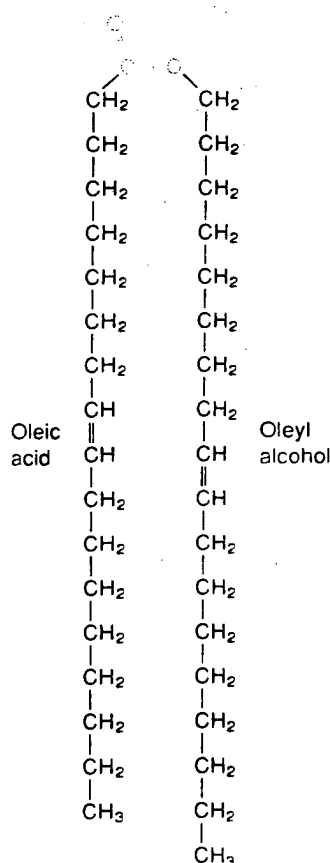
Esterification with glycerol greatly diminishes the hydrophilic character of the head groups of the fatty acids. As a consequence, not only are triacylglycerols water-insoluble, they do not even form micelles very effectively. Fats are therefore stored in plant and animal cells as oily droplets in the cytoplasm. In adipocytes, animal cells specialized for fat storage, almost the entire volume of each cell is filled by a fat droplet (Figure 9.3). Such cells make up most of the adipose (fatty) tissue of animals.

Fat storage in animals serves three distinct functions:

1. Most fat in most animals is oxidized for the generation of ATP, to drive metabolic processes.
2. Some specialized cells (in "brown fat" of warm-blooded animals, for example) oxidize the triacylglycerols for heat production, rather than to make ATP.
3. In animals that must live in a cold environment, layers of fat cells under the skin serve as thermal insulation.

## Waxes

In the natural waxes, a long-chain fatty acid is esterified to a long-chain alcohol (Figure 9.4). This yields a head group that is only weakly hydrophilic, attached to two hydrocarbon chains. As a consequence, the waxes are completely water-insoluble. In fact, they are so hydrophobic that they often serve as water repellents, as in the feathers of some birds and the leaves of some plants. In some marine microorganisms, waxes are used instead of other lipids for energy storage. As with the triacylglycerols, the hardness of waxes is determined by chain length and degree of hydrocarbon saturation.



**Figure 9.4**  
Structure of a typical wax. Waxes are formed by esterification of fatty acids and long-chain alcohols. The small head group (blue) can contribute little hydrophilicity, as compared to the hydrophobic contribution of the two long tails.

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